



## SEA WATER FREEZE

**Unit:** *Salinity Patterns & the Water Cycle*

**Grade Level:** *Middle*

**Time Required:** *3 class periods*

**Content Standard:** *Physical Science*

**Principles:** *Properties of matter: Substances have characteristic properties (e.g., density) that are independent of sample amount.*

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### Student Learning Objectives

- Observe how salinity affects the time it takes water to freeze
- Understand that salt is left behind as salt water freezes, this process forms brine
- Through experimentation, learn that ice is salt-free whether it is formed from fresh or salt water
- Learn about sea ice vs. icebergs; see that they float higher in salt water than in fresh water

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**BACKGROUND:** *Sea ice is frozen seawater that floats on the ocean surface. Blanketing millions of square kilometers near the North and South Poles, sea ice can form and melt during different seasons, affecting both human activity and biological habitat. Almost all Antarctic sea ice (near the South Pole) melts away and re-forms each year. On the other hand, in the Arctic (near the North Pole) some sea ice persists year after year. Icebergs are also important in polar regions. Unlike sea ice that is formed from salty seawater, icebergs are composed of ice originating from land-based glaciers that flow into the sea. Glaciers are formed by snow that accumulates on mountains over many years. Ask the students whether snow is made of saltwater or freshwater. How do they know this? (Taste.)*

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**Materials:** *Per Student Group – one cup of ordinary table salt, tablespoon, plastic ice tray with divided watertight sections, tap water, thermometer, 8 jars (at least 8 oz.), beakers (at least 300 ml) or cut 2L plastic soda bottles, ruler, graph paper.*

**Preparation:** *Students will need access to a freezer. An earth globe will also be shown to the students.*

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### Activity

- Begin with a class discussion of the locations of the North Pole (Arctic) and South Pole (Antarctic). Ask the students which Pole is covered by land (Antarctic) and which is covered by seawater (Arctic). Ask students which Pole is more likely to have glaciers nearby (North Pole).
- Ask the class to hypothesize about the affect of water salinity – or amount of salt – on the formation and buoyancy of sea ice. Do they think ice formed from salt water will freeze more quickly or more slowly than fresh water? Do they think that sea ice (i.e., formed from salty water) will be more buoyant or less buoyant than ice formed from fresh water (e.g., icebergs)? Do they think that the size of sea ice or icebergs affects their buoyancy (e.g., percentage above and below the water line)?
- Label 8 jars as follows: 2 marked “A”; 2 marked “B”; two marked “C”; and two marked “D.” In each jar mix salt and water solutions as follows:
  - In each jar marked “A”: mix 9 T salt with 1 cup water
  - In each jar marked “B”: mix 6 T salt with 1 cup water
  - In each jar marked “C”: mix 3 T salt with 1 cup water
  - In each jar marked “D”: 1 cup pure tap water
- **NOTE:** *One set of jars A-D will be used to fill an ice cube tray. Put the second set in a refrigerator if available, otherwise set them aside in a cool, shaded area of the room.*
- Label each quarter section of the ice cube tray as section A, B, C, and D.
- Pour one set of solutions A - D into their labeled sections of the ice cube tray. Ask the students to make a variety of ice cube sizes using each solution. Place the tray in the freezer.

- Using a data chart ("Freezer Experiment" table provided at bottom), students observe and record water temperature and conditions after 1 hour, 24 hours, and 48 hours. Water temperatures are taken in the liquid water, under any ice formations, if present. If not present, draw an "X" through that data entry. Conditions include degree of solidity, color, texture, volume, layering, etc.
- With teacher permission, have a volunteer taste an iceberg from each section and record results.
- At the end of 48 hours and using graph paper, plot a line graph of temperatures.
- Using the second set of solutions (A - D) that were set aside, conduct a series of buoyancy tests. On data chart ("Buoyancy Experiment" table provided at bottom), test and record how well each kind of ice (A, B, C, D) floats in each solution (A, B, C, D). Students should use their own judgment on how to qualify the relative buoyancy of "icebergs" in each solution. (The teacher could suggest that they use a ruler to estimate the percentage of ice above and below the water line.)

### Assessment / Questions

- Did any solution not freeze? If so, which one? (Although it depends upon the experimental conditions, the highest salt concentration, "A", will likely not completely freeze. Highly saline solutions such as this are called "brine.")
- Which solution was first to freeze? (Usually "D" is the first to freeze.)
- Using graphed results, explain what happens to the ability of water to freeze as you add more and more salt. (The higher the salinity, the longer it takes to freeze. This is because the higher the salinity, the lower the freezing point.)
  - OPTIONAL: To access an interactive animation depicting the interaction of ice, water, and a solute (e.g., salt), visit the "General Chemistry Online!" webpage, "Why does salt melt ice?" (<http://antoine.frostburg.edu/chem/senese/101/solutions/faq/why-salt-melts-ice.shtml>). Raise and lower the temperature and "add solute" by clicking on the banner below the "dancing" water molecules. Ask students how this animation relates to their experiment results.
- Have groups discuss whether the findings confirm their initial hypotheses. (Students may have been surprised to find that salt water freezes more slowly than fresh water and, when salt content is high enough, may not freeze at all. They may also be surprised to learn their ice cubes are most buoyant in the saltiest solution, "A" in this case. Many will not have guessed that all the ice cubes would free of salt and thus "ice type" did not affect buoyancy. Also, many will not have guessed that the size of each ice cube does not affect the percentage above and below the water line.)
- Is ice formed from salt water salty or fresh? (Fresh.) How does this relate to sea ice and icebergs in the Arctic and Antarctica? (Both sea ice and icebergs are essentially salt-free.) Look at the photos below: "Sea ice photos from the Arctic" and "Iceberg photos from the Antarctic". How can you explain differences in their physical appearance? (The sea ice shown is thinner and flatter having formed from seawater; the icebergs are large and layered from years of snow accumulation.)

### Vocabulary

- **brine:** Water saturated with or containing large amounts of a salt, especially sodium chloride.
- **buoyancy:** In physics, an upward force on an object immersed in a fluid (i.e. a liquid or gas), enabling it to float or at least to appear to become lighter. If the buoyancy exceeds the weight, then the object floats; if the weight exceeds the buoyancy, the object sinks.
- **freezing point:** Temperature at which a liquid of specified composition solidifies under a specified pressure.
- **glacier:** A large mass of ice, formed from compacted snow, whose sides are often bounded by mountains or the walls of a valley. Ice sheets or caps, also formed from compacted snow, are so massive that they cover entire landscapes, mountains as well as valleys. Where glaciers and ice sheets flow slowly toward the sea chunks may break off and produce icebergs.
- **hypothesis:** A proposed explanation for a phenomenon.
- **iceberg:** A floating body of ice broken off a glacier. About 10% of its mass lies above the water surface.
- **polar:** Located at or near the earth's North or South pole.
- **salinity:** Saltiness or dissolved salt content of a body of water.
- **sea ice:** Ice that is formed by the freezing of sea water.
- **solute:** A substance dissolved in another substance (the solvent) to create a solution.

**Original source:** Adapted from UCLA Marine Science Center's OceanGLOBE "Density & Salinity Lesson Plan"

**Aquarius Education & Public Outreach URL:** <http://www.bigelow.org/aquarius>

FREEZER EXPERIMENT							
JAR	Starting salt / water content	Record your observations below:					
		1 hour in freezer		24 hours in freezer		48 hours in freezer	
		Temp	Notes	Temp	Notes	Temp	Notes
A							
B							
C							
D							

BUOYANCY EXPERIMENT				
	Ice from "A"	Ice from "B"	Ice from "C"	Ice from "D"
Solution "A"				
Solution "B"				
Solution "C"				
Solution "D"				

**Sea ice photos from the Arctic**



**Iceberg photos from the Antarctic**



*Photos from Bigelow Laboratory for Ocean Sciences and the Australian Antarctic Division*